STORMWATER DRAINAGE DESIGN OVERVIEW

4.1.1 Stormwater Drainage System Design

4.1.1.1 Introduction

Stormwater drainage design is an integral component of both site and overall stormwater management design. Good drainage design must strive to maintain compatibility and minimize interference with existing drainage patterns; control flooding of property, structures and roadways for design flood events; and minimize potential environmental impacts on stormwater runoff.

Stormwater collection systems must be designed to provide adequate surface drainage while at the same time meeting other stormwater management goals such as water quality, streambank channel protection, habitat protection and groundwater recharge.

4.1.1.2 Drainage System Components

In every location there are two stormwater drainage systems, the minor system and the major system. Three considerations largely shape the design of these systems: flooding, public safety and water quality.

The minor drainage system is designed to remove stormwater from areas such as streets and sidewalks for public safety reasons. The minor drainage system consists of inlets, street and roadway gutters, roadside ditches, small channels and swales, and small underground pipe systems which collect stormwater runoff and transport it to structural control facilities, pervious areas and/or the major drainage system (i.e., natural waterways, large man-made conduits, and large water impoundments).

Paths taken by runoff from very large storms are called major systems. The major system (designed for the less frequent storm up to the 100-yr level) consists of natural waterways, large man-made conduits, and large water impoundments. In addition, the major system includes some less obvious drainageways such as overload relief swales and infrequent temporary ponding areas. The major system includes not only the trunk line system that receives the water from the minor system, but also the natural backup system which functions in case of overflow from or failure of the minor system. Overland relief must not flood or damage houses, buildings or other property.

The major/minor concept may be described as a system within a system for it comprises two distinct but conjunctive drainage networks. The major and minor systems are closely interrelated, and their design needs to be done in tandem and in conjunction with the design of structural stormwater controls and the overall stormwater management concept and plan (see Section 1.5).

This chapter is intended to provide design criteria and guidance on several drainage system components, including street and roadway gutters, inlets and storm drain pipe systems (Section 4.2); culverts (Section 4.3); vegetated and lined open channels (Section 4.4); and energy dissipation devices for outlet protection (Section 4.5). The rest of this section covers important considerations to keep in mind in the planning and design of stormwater drainage facilities.

4.1.1.3 Checklist for Drainage Planning and Design

The following is a general procedure for drainage system design on a development site.

(1) Analyze topography

a) Check off-site drainage pattern. Where is water coming onto the site? Where is water leaving the site?

b) Check on-site topography for surface runoff and storage, and infiltration

1. Determine runoff pattern; high points, ridges, valleys, streams, and swales. Where is the water going?
2. Overlay the grading plan and indicate watershed areas; calculate square footage (acreage), points of concentration, low points, etc.

c) Check potential drainage outlets and methods

1. On-site (structural control, receiving water)
2. Off-site (highway, storm drain, receiving water, regional control)
3. Natural drainage system (swales)
4. Existing drainage system (drain pipe)

(2) Analyze other site conditions.

a) Land use and physical obstructions such as walks, drives, parking, patios, landscape edging, fencing, grassed area, landscaped area, tree roots, etc.

b) Soil type determines the amount of water that can be absorbed by the soil.

c) Vegetative cover will determine the amount of slope possible without erosion.

(3) Analyze areas for probable location of drainage structures and facilities.

(4) Identify the type and size of drainage system components that are required. Design the drainage system and integrate with the overall stormwater management system and plan.

4.1.2 Key Issues in Stormwater Drainage Design

4.1.2.1 Introduction

The traditional design of stormwater drainage systems has been to collect and convey stormwater runoff as rapidly as possible to a suitable location where it can be discharged. This Manual takes a different approach wherein the design methodologies and concepts of drainage design are to be integrated with the objectives for water quantity and quality control in the stormwater management minimum standards. This means that:

- Stormwater conveyance systems are to remove water efficiently enough to meet flood protection criteria and level of service requirements, and
- These systems are to complement the ability of the site design and structural stormwater controls to mitigate the major impacts of urban development.

The following are some of the key issues in integrating water quantity and quality control consideration in stormwater drainage design.

4.1.2.2 General Drainage Design Considerations

- Stormwater systems should be planned and designed so as to generally conform to natural drainage patterns and discharge to natural drainage paths within a drainage basin. These natural drainage paths should be modified as necessary to contain and safely convey the peak flows generated by the development.

- Runoff must be discharged in a manner that will not cause adverse impacts on downstream properties or stormwater systems. In general, runoff from development sites within a drainage basin should be discharged at the existing natural drainage outlet or outlets. If the developer wishes to change discharge points he or she must demonstrate that the change will not have any adverse impacts on downstream properties or stormwater systems.
- It is important to ensure that the combined minor and major system can handle blockages and flows in excess of the design capacity to minimize the likelihood of nuisance flooding or damage to private properties. If failure of minor systems and/or major structures occurs during these periods, the risk to life and property could be significantly increased.
- In establishing the layout of stormwater networks, it is essential to ensure that flows will not discharge onto private property or roadways during flows up to the major system design capacity.

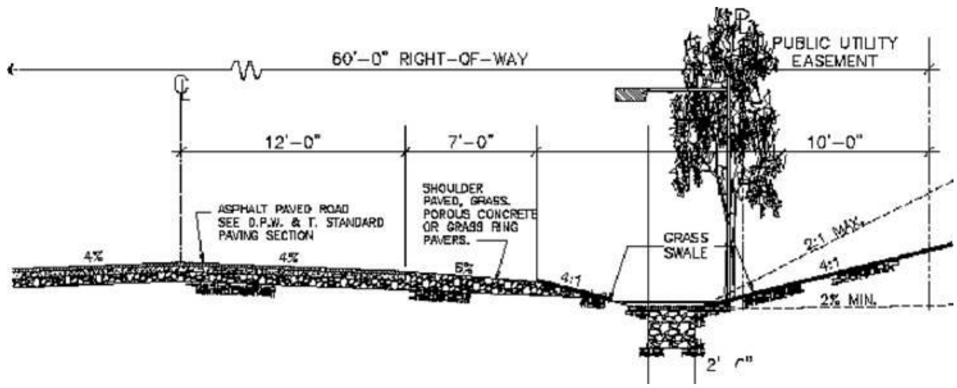

Figure 4.1-1 Alternate Roadway Section without Gutters
(Source: Prince George's County, MD, 1999)

4.1.2.3 Inlets and Drains

- Inlets should be located to maximize overland flow path, take advantage of pervious areas, and seek to maximize vegetative filtering and infiltration. For example, it might be possible to design a parking lot so that water flows into vegetated areas prior to entering the nearest inlet.
- Inlet location should not compromise safety or aesthetics. It should not allow for standing water in areas of vehicular or pedestrian traffic, but should take advantage of natural depression storage where possible.
- Inlets should be located to serve as overflows for structural stormwater controls. For example, a bioretention device in a commercial area could be designed to overflow to a catch basin for larger storm events.
- The choice of inlet type should match its intended use. A sumped inlet may be more effective supporting water quality objectives.
- Use several smaller inlets instead of one large inlet in order to:
    (1) Prevent erosion on steep landscapes by intercepting water before it accumulates too much volume and velocity.
    (2) Provide a safety factor. If a drain inlet clogs, the other surface drains may pick up the water.
    (3) Improve aesthetics. Several smaller drains will be less obvious than one large drain.
    (4) Spacing smaller drain inlets will give surface runoff a better chance of reaching the drain. Water will have farther to travel to reach one large drain inlet.

4.1.2.4 Storm Drain Pipe Systems (Storm Sewers)

- The use of better site design practices (and corresponding site design credits) should be considered to reduce the overall length of a piped stormwater conveyance system.
- Shorter and smaller conveyances can be designed to carry runoff to nearby holding areas, natural conservation areas, or filter strips (with spreaders at the end of the pipe).
- Ensure that storms in excess of pipe design flows can be safely conveyed through a development without damaging structures or flooding major roadways. This is often done through design of both a major and minor drainage system. The minor (piped) system carries the mid-frequency design flows while larger runoff events may flow across lots and along streets as long as it will not cause property damage or impact public safety.

4.1.2.5 Culverts

- Culverts can serve double duty as flow retarding structures in grass channel design. Care should be taken to design them as storage control structures if depths exceed several feet, and to ensure safety during flows.
- Improved inlet designs can absorb considerable slope and energy for steeper sloped designs, thus helping to protect channels.

4.1.2.6 Open Channels

- Open channels provide opportunities for reduction of flow peaks and pollution loads. They may be designed as wet or dry enhanced swales or grass channels.
- Channels can be designed with natural meanders improving both aesthetics and pollution removal through increase of contact time.
- Grass channels generally provide better habitat than hardened channel sections, though studies have shown that riprap interstices provide significant habitat as well. Velocities should be carefully checked at design flows and the outer banks at bends should be specifically designed for increased shear stress.
- Compound sections can be developed that carry the annual flow in the lower section and higher flows above them. Figure 4.1-2 illustrates a compound section that carries the 2-year and 25-year flows within banks. This reduces channel erosion at lower flows, and meandering, self-forming low flow channels that attack banks. The shelf in the compound section should have a minimum 1:12 slope to ensure drainage.

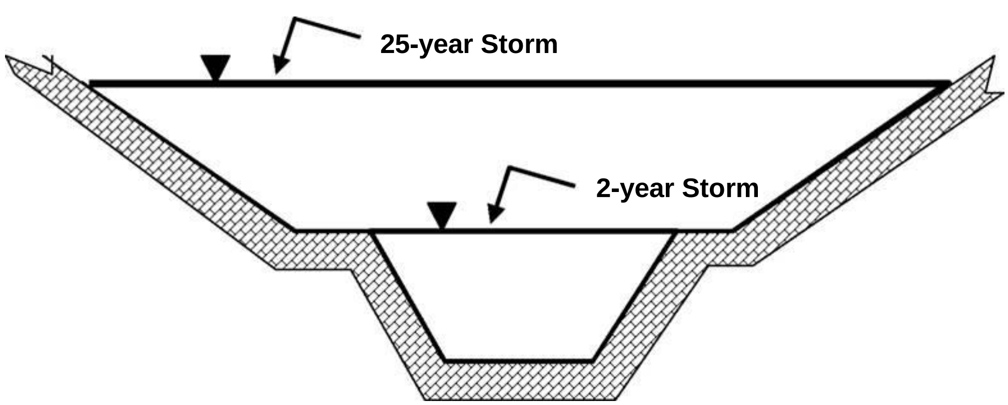

Figure 4.1-2 Compound Channel

- Flow control structures can be placed in the channels to increase residence time. Higher flows should be calculated using a channel slope that goes from the top of the cross piece to the next one if it is significantly different from the channel bottom for normal depth calculations. Channel slope stability can also be ensured through the use of grade control structures that can serve as pollution reduction enhancements if they are set above the channel bottom. Regular maintenance is necessary to remove sediment and keep the channels from aggrading and losing capacity for larger flows.

4.1.2.7 Energy Dissipators

- Energy dissipators should be designed to return flows to non-eroding velocities to protect downstream channels.
- Care must be taken during construction that design criteria are followed exactly. The designs presented in this Manual have been carefully developed through model and full-scale tests. Each part of the criteria is important to the proper function.

4.1.3 Design Storm Recommendations

Listed below are the design storm recommendations for various stormwater drainage system components to be designed and constructed in accordance with the minimum stormwater management standards. It is required that the full build- out conditions be used to calculate flows for the design storm frequencies below.

Storm Drainage Systems

Storm drains shall be designed to the 25-year frequency storm. The overall storm drainage system shall be evaluated for the 100-year frequency storm and surface flooding conditions at the discretion of Columbia County. The hydraulic grade line for the 25-year and the 100-year (if applicable) frequency storms shall be shown and labeled on the profile sheets.

- 25-year design storm (for pipe and culvert design under gravity flow conditions)
- 25-year design storm (for inlet design)
- 50-year design storm (for sumped inlets, unless overflow facilities are provided)

Roadway Culvert Design

Cross drainage facilities that transport storm runoff under roadways.

- 100-year design storm with backwater elevations not exceeding a height twelve (12) inches below the shoulder of the roadway, or in accordance with GA DOT requirements, whichever is more stringent. (Criteria to be taken into consideration when selecting design flow include roadway type, depth of flow over road, structures and property subject to flooding, emergency access, and road replacement costs)
- In outlet control conditions, the determination of tail water depth shall be included in the design.

Open Channel Design

Open channels include all channels, swales, etc.

- 25-year design storm

Channels may be designed with multiple stages (e.g., a low flow channel section containing the 2-year to 5-year flows, and a high flow section that contains the design discharge) to improve stability and better mimic natural channel dimensions. Where flow easements can be obtained and structures kept clear, overbank areas may also be designed as part of a conveyance system wherein floodplain areas are designed for storage and/or conveyance of larger storms.

Energy Dissipation Design Includes all outlet protection facilities.

- 25-year design storm
- Additional energy dissipation devices/structures shall be required at outlets to control velocity.

Check Storm

Used to estimate the runoff that is routed through the drainage system and stormwater management facilities to determine the effects on the facilities, adjacent property, floodplain encroachment and downstream areas.

- 100-year design storm, or as required by the Georgia Safe Dams Act.